A Comparison of the Results of a Volunteer Stream Quality Monitoring Program and the Ohio EPA's Biological Indices

Mark A. Dilley*
School of Natural Resources
The Ohio State University
2021 Coffey Road
Columbus, OH 43210

Abstract
Volunteer stream quality monitoring is increasing in popularity around the country, and organizations involved with the administration of volunteer stream quality monitoring programs are becoming interested in the effectiveness of their monitoring techniques. This research compares the results of the Ohio Department of Natural Resources (ODNR) volunteer-oriented Scenic Rivers Stream Quality Monitoring Program and the Ohio Environmental Protection Agency's (OEPA) biological assessments. The volunteer biological monitoring ("kick-seining") technique was performed on 12 Ohio rivers and tributaries, at 47 different sites, to coincide with the OEPA's monitoring agenda for the summer of 1989. Comparisons were made between the volunteer stream quality monitoring ratings and the OEPA's Index of Biotic Integrity (IBI) and Invertebrate Community Index (ICI). Sites which were rated "excellent" using the ODNR volunteer method tended to meet the OEPA's criteria for attainment of aquatic life uses for both the IBI and ICI. Sites which were determined to be "fair" or "poor" with the volunteer method corresponded to IBI and ICI scores falling in the non-attainment of aquatic life uses range. Although revisions in the sampling and rating system for the volunteer program could improve the predictive value of these results as compared to OEPA's indices, the volunteer technique assessments currently appear to have merit when interpreted in terms of aquatic life use attainment or non-attainment.

Key Words: volunteer monitoring, biological indices, stream quality, kick-seining, Ohio, Scenic Rivers.

Introduction

In 1983, the Ohio Department of Natural Resources (ODNR) developed the Ohio Scenic Rivers Stream Quality Monitoring Program with assistance from the Ohio Environmental Protection Agency (OEPA). This program uses volunteers to conduct simple stream quality assessments at designated monitoring stations on the state's ten Scenic Rivers. ODNR's stream quality monitoring technique involves assessments based on the presence or absence of 20 taxa of macroinvertebrates which are divided into three categories, according to each groups pollution tolerance level (Fig. 1).

Group One, the pollution intolerant organisms, includes mayfly and stonefly nymphs, dobsonfly, caddisfly and water penny beetle larvae, riffle beetles, and gill-breathing snails. Group Two macroinvertebrates, with intermediate pollution tolerances, include dragonfly and damselfly nymphs, beetle and cranefly larvae, scuds, crayfish, sowbugs, and clams. Group Three, the pollution tolerant organisms, consists of aquatic worms, pouch snails, black fly and midge larvae, and leeches. Many of the taxa used in the program encompass entire orders (i.e. mayflies - Order Ephemeroptera, caddisflies - Order Trichoptera) so identification is not refined.

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* Current address: Metcalf & Eddy, Inc., 2800 Corporate Exchange Drive, Suite 250, Columbus, Ohio 43231

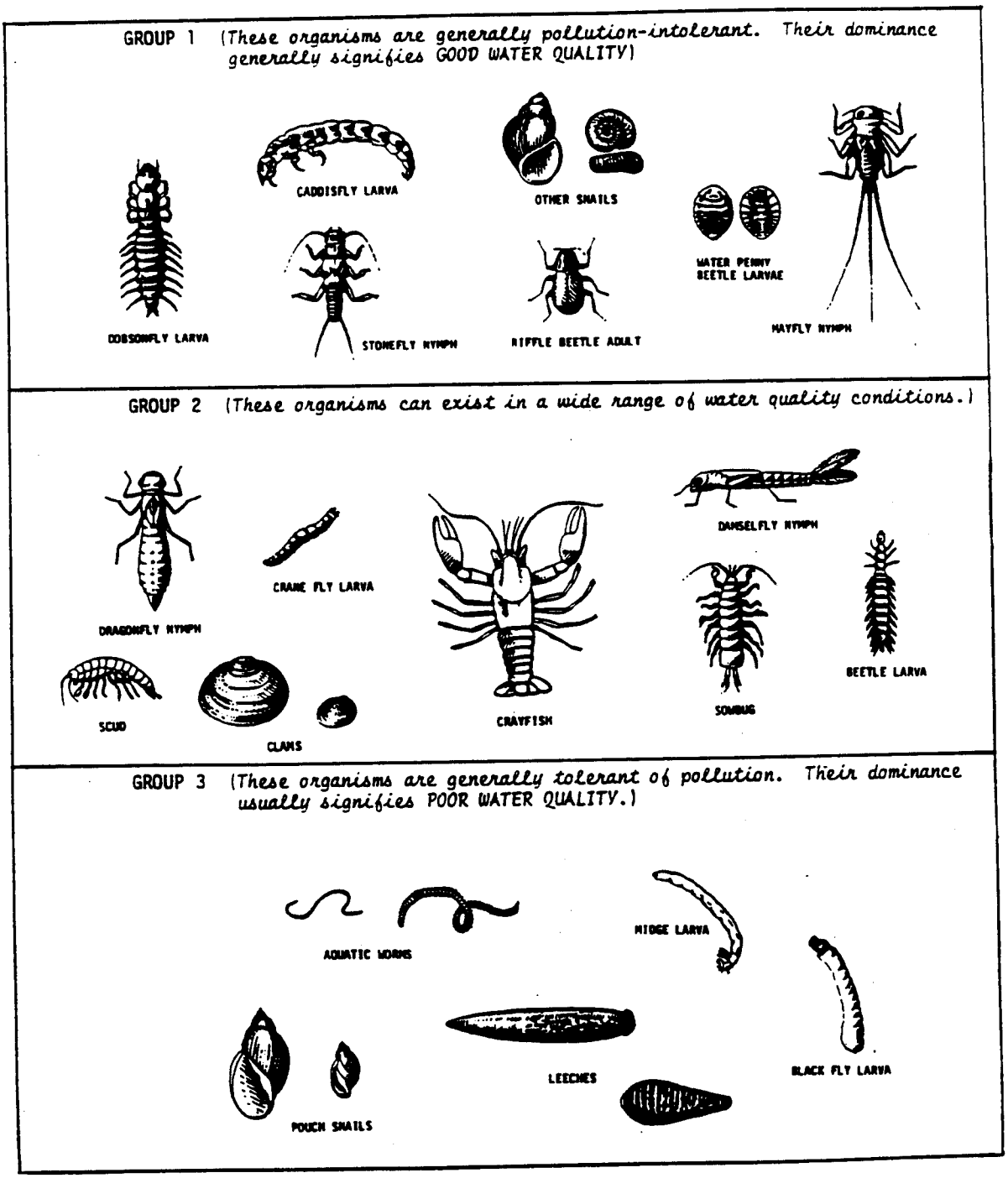


Figure 1. Ohio Department of Natural Resources Scenic Rivers Stream Quality Monitoring Program macroinvertebrate identification sheet with pollution-tolerance groupings.

In this Stream Quality Monitoring Program, volunteers collect macroinvertebrates from riffles using the "kick-seine" technique. Riffles, with little or no vegetation and stones up to 15 inches in diameter, are the type of habitat best suited to this method of sampling (Frost et al. 1971). The "kick-seine" technique involves disturbing the substrate upstream of the seine to dislodge the macroinvertebrates which cling to, and hide under the rocks and debris in the riffle. Once freed of the substrate, the macroinvertebrates are carried by the current into the seine. After a sample has been collected, the seine is taken to the stream bank where the organisms are hand-picked from the net and identified on site. Macroinvertebrates often exhibit patchy distributions in streams (Rabeni and Minshall 1977, Schwenneker and Hellenthal 1984). Therefore, volunteers are encouraged to take samples from a variety of habitats until they feel that no new taxa are represented in their samples. No set number of samples has ever been established for the program, however.

After all the samples have been collected, volunteers fill out an assessment form indicating the station sampled (according to OEPA river miles), water conditions such as clarity, algal bedgrowths, and odor, and the macroinvertebrate groups found (Fig. 2). For each macroinvertebrate taxon group located at the station, an estimated count letter code is entered on the assessment form. The letter codes A, B, and C represent 1 to 9, 10 to 99, and 100 or more individuals, respectively. Using estimated counts allows the ODNR staff to get an idea of population sizes while not placing the burden of counting the organisms on the program volunteers.

The final assessment score, referred to as the Cumulative Index Value, or CIV, is based only on the diversity of macroinvertebrates found and not the quantity. In the scoring system, each Group One taxon in the sample receives a point value of three, each Group Two taxon, a point value of two, and each Group Three taxon, a point value of one. The CIV is the sum of the points given to each category. The final step in the stream quality assessment is determining a qualitative rating for the station based on the CIV. Cumulative Index Values of over 22 are given an "excellent" rating. Scores between 17 and 22 are rated "good." "Fair" is 11-16, and a "poor" rating is given to scores of less than 11.

Once completed, assessments are sent to ODNR where they are entered into a computer database. The database allows for a quick review of the history of a given monitoring station to determine if the site has experienced any significant impacts over the years it has been monitored. It is believed that this may allow for early detection of degradation on the Scenic Rivers. The Ohio Department of Natural Resources stresses that the procedure "is not intended to pinpoint subtle changes in water quality, but rather the general condition of the river," and that "information which indicates potential decreases in water quality will be coordinated with the Ohio Environmental Protection Agency." (ODNR n.d.). The program is not intended to completely assess the source or degree of degradation, but rather provide an inexpensive and enjoyable way for the public to flag the attention of responsible enforcement agencies in the event that further study may be warranted.

The simplicity and accessibility of the program has made it popular among schools, conservation groups, scouts, and families. Since its beginning, the Stream Quality Monitoring Program has grown quite rapidly. During the 1990 monitoring season, approximately 3,000 volunteers monitored Ohio's Scenic Rivers. In addition to this considerable volunteer force, many Soil and Water Conservation Districts in Ohio have expressed interest in ODNR's method to develop volunteer stream quality monitoring programs for streams within their counties

STREAM QUALITY ASSESSMENT FORM

STATION _____ STREAM _____ SAMPLE # _____

LOCATION _____

COUNTY _____ TOWNSHIP/CITY _____ DATE _____ TIME _____

GROUP OR INDIVIDUALS _____ NO. OF PARTICIPANTS _____

DESCRIBE WATER CONDITIONS (COLOR, ODOR, BEDGROWTHS, SURFACE SCUM, ETC.)

HACH KIT RESULTS (if used) AND OTHER OBSERVATIONS

USE BACK OF FORM IF NECESSARY

WIDTH OF RIFFLE _____

WATER DEPTH _____

WATER TEMP. (°F) _____

BED COMPOSITION OF RIFFLE (%)

SILT ☐ SAND ☐ GRAVEL (¼"- 2") ☐

COBBLES (2"- 10") ☐ BOULDERS (> 10") ☐

MACROINVERTEBRATE TALLY

ESTIMATED COUNT LETTER CODE

A = 1 to 9
B = 10 to 99
C = 100 or more

GROUP 1 TAXA	LETTER CODE	GROUP 2 TAXA	LETTER CODE	GROUP 3 TAXA	LETTER CODE
WATER PENNY LARVAE		DAMSELFLY NYMPHS		BLACKFLY LARVAE	
MAYFLY NYMPHS		DRAGONFLY NYMPHS		AQUATIC WORMS	
STONEFLY NYMPHS		CRANE FLY LARVAE		MIDGE LARVAE	
DOBSONFLY LARVAE		BEETLE LARVAE		POUCH SNAILS	
CADDISFLY LARVAE		CRAYFISH		LEECHES	
RIFFLE BEETLE ADULT		SCUDS			
OTHER SNAILS		CLAMS			
		SOWBUGS			
NUMBER OF TAXA (times) INDEX VALUE 3		NUMBER OF TAXA (times) INDEX VALUE 2		NUMBER OF TAXA (times) INDEX VALUE 1	

CUMULATIVE INDEX VALUE ☐

STREAM QUALITY ASSESSMENT

EXCELLENT (> 22) ☐ GOOD (17-22) ☐

FAIR (11-16) ☐ POOR (< 11) ☐

PLEASE SEND THIS FORM TO:

Mr. John S. Kopec, Planning Supervisor
Division of Natural Areas and Preserves
Ohio Scenic Rivers Program
1889 Fountain Square Court
Columbus, Ohio 43224 Phone: (614) 265-6458

Figure 2. Ohio Department of Natural Resources Scenic Rivers Stream Quality Monitoring Program assessment form.

(Kopec 1989). Other states and private organizations are also patterning programs after ODNR's technique.

Generally, identification of invertebrates to only the order level of classification is considered to have limited ecological meaning. Species level identification is necessary for a more sensitive measure of water quality. (Resh and Unzicker 1975). This fact, and the increasing interest in ODNR's Stream Quality Monitoring Program, caused OEPA and ODNR staff to question quality assurance and quality control for the program.

To examine the accuracy of ODNR's stream quality monitoring technique, a source of reliable stream health information was needed for comparison. James Karr (1981) stated that it would be impossible, because of the complexity of stream ecosystems, to ever recognize all the potential factors that may impact biological communities. Although no techniques exist which can fully acknowledge all the processes at work in an aquatic ecosystem, biological monitoring integrates the effects of many processes that occur in streams. To assess stream health, the OEPA uses biological indices which have been closely studied and tested, making the OEPA's methods the best available source of stream health and biological integrity information in Ohio.

The OEPA monitors rivers and streams using three primary indices as criteria for assessment. The Index of Biotic Integrity, or IBI, originated by Karr (1981), is based on fish populations. Invertebrate samples are used to compile the Invertebrate Community Index, or ICI. The third index, the Index of Well-being, or Iwb, was not examined in this study. These indices are used to rate the relative quality of Ohio's rivers and are translated into ratings of "exceptional, good, fair, poor, and very poor." The reason for the use of more than one organism group (fish and invertebrates) is explained in the OEPA publication Biological Criteria for the Protection of Aquatic Life: Volume I, which states "The need to use both groups is apparent in the ecological differences between them, differences that tend to be complementary in an environmental evaluation" (Ohio EPA 1988).

In order to address the quality assurance/quality control issue for ODNR's Stream Quality Monitoring Program, this research examined the correlation between the OEPA's indices (IBI and ICI) and ODNR's CIV and also the agreement between ODNR staff- and volunteer-generated stream quality assessments. The general objective of this paper is to illustrate how accurately the results of ODNR's simple approach to biological monitoring can reflect stream health assessments based on more sophisticated approaches.

Methods and Materials

Over the summer of 1989 (late June to mid-September), the standard ODNR stream quality monitoring technique (as described above) was performed on 12 of Ohio's rivers and tributaries which were also being monitored by the OEPA (Fig. 3). The sites on these rivers represented a variety of habitat and impact types. With the help of the OEPA's staff, a sampling schedule was arranged which closely adhered to their agenda. This was done to help reduce the effects of seasonal or temporary variations in stream quality. All ODNR stream quality assessments were made within 0.8 river miles of the area sampled by the OEPA and all ODNR assessments were made within two weeks of OEPA's testing.

A 9 in. high, 18 in. wide rectangular frame 1/32 in. mesh dip net was substituted for the seine to allow for solo collections. This type of net and the standard 1/16 in. mesh seine are used interchangeably in ODNR's program to allow stream quality monitoring coordinators to make collections alone. At

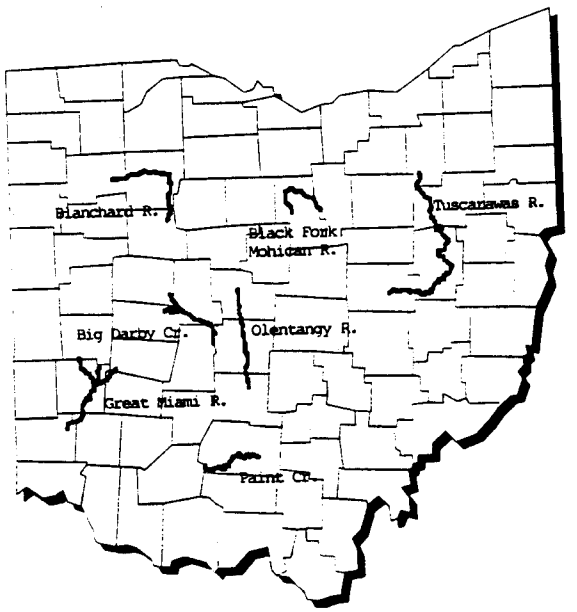


Figure 3. Ohio rivers monitored in study.

each site sampled, four regular samples were collected from areas approximately 9 ft. square and a search was conducted along the stream's edge for macroinvertebrates such as dragonfly naiads, which may prefer slower water velocity or vegetation. An index value was calculated for each sample and a CIV was calculated for the riffle. The CIV was then translated into a qualitative rating. Assessments were made on 37 different sites for comparison with the IBI, and many of those sites were monitored twice, resulting in 56 assessment records. For the comparison with the ICI, 30 assessment records from 30 sites were collected. The data were entered into a FoxBase Mac database.

In the spring of 1990, the OEPA finished processing all of its 1989 data, and their assessments were merged into a master database. The study sites were then examined for correlations between ODNR's stream quality monitoring results and the indices of OEPA, the IBI and ICI.

To examine volunteer accuracy, ODNR's volunteer monitoring database was searched for sites which were monitored both by staff members and volunteers within a three month period of time. Matched records in which one sample was taken in the early months of spring and the other in the summer were discarded, due to the notable changes in benthic community composition between these time periods. Spring CIVs are typically higher and are usually not comparable to summer CIVs. Over 200 usable matched records were located in the database.

Results and Discussion

Comparison of the IBI and ODNR's CIV

For sites rated "excellent" by ODNR's method, corresponding IBIs ranged from 30 to 57 (Fig. 4). This range includes IBIs which the OEPA would consider indicative of "fair" to "exceptional" conditions. The CIV ratings did not match exactly those of the OEPA. However, 86% of the corresponding IBIs did fall at a value of 40 or above, indicating attainment of aquatic life uses, as designated by the OEPA. For sites rated "good," the corresponding IBIs again showed a wide range, with approximately half the values indicating that sites did attain aquatic life uses, while the other half indicated that sites did not attain life uses. All "fair" and "poor" ratings were observed at sites where IBIs were less than 40, indicating non-attainment of life uses.

A primary reason for lack of complete agreement between the CIV and IBI qualitative ratings is the inherent differences between the indices. The IBI is an index based on fish collected from a 200 meter reach of stream and ODNR's CIV is based on macroinvertebrates sampled from a riffle only. However, another factor, drainage area, was found to affect the correlation. The OEPA designates sampling sites as headwater, wading, and boat sites, based on the drainage area. When the boat sites were eliminated

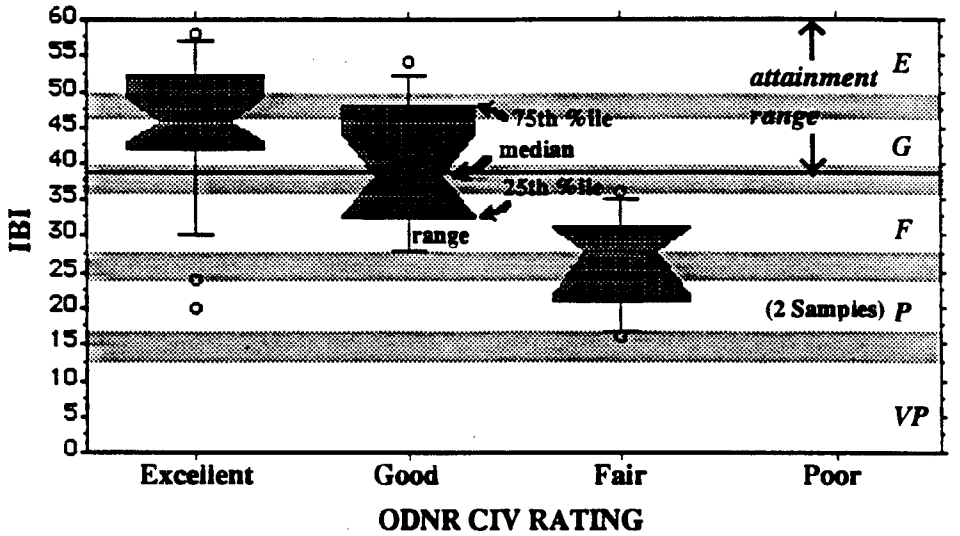


Figure 4. Notched box plots of Cumulative Index Value (CIV) qualitative ratings versus Index of Biotic Integrity (IBI) scores, 25th and 75th percentiles, IBI range, and IBI outliers (>2 interquartile ranges from median). IBI qualitative ratings (exceptional, good, fair, poor, and very poor) appear on the right vertical axis. Shading indicates approximate boundaries between ratings and the variability of the index.

from the comparison, the definition between ODNR's qualitative ratings and the corresponding IBIs increased (Fig. 5). The median IBI score for each corresponding ODNR rating fell in the correct qualitative range for the IBI, and the IBI ranges for the "excellent" and "good" ratings were shortened and more defined. The IBI range for sites rated "good" was still considerably large, but it was centered in the correct IBI qualitative range. For "fair" sites, all IBIs fell in the non-attainment range of less than 40. A box plot of those sites with drainage areas greater than 200 square miles further illustrates the impact of drainage area. (Fig. 6). Notice that, for sites of larger drainage, there is no detectable definition between sites rated "excellent" and "good" and the corresponding IBIs. The IBI ranges for the CIV ratings are notably similar.

Comparison of the ICI and ODNR's CIV

For sites rated "excellent" by ODNR's method, ICIs ranged from 41 to 57 (Fig. 7). This range includes ICIs which the OEPA would consider "good" to "exceptional." As in the IBI comparison, the CIV ratings did not exactly match the ICI ratings of the OEPA. However, all of the ICIs corresponding to the "excellent" rating did fall at a value of 35 or above, indicating attainment of aquatic life uses, as designated by the OEPA for the ICI. For sites rated "good," the corresponding ICIs showed a wide range, with approximately 62% of the values indicating attainment of aquatic life uses, while the other 38% of the values indicated non-attainment. ICI values were less than 35 at sites where "fair" ODNR results were observed, indicating non-attainment of life uses. No "poor" sites for

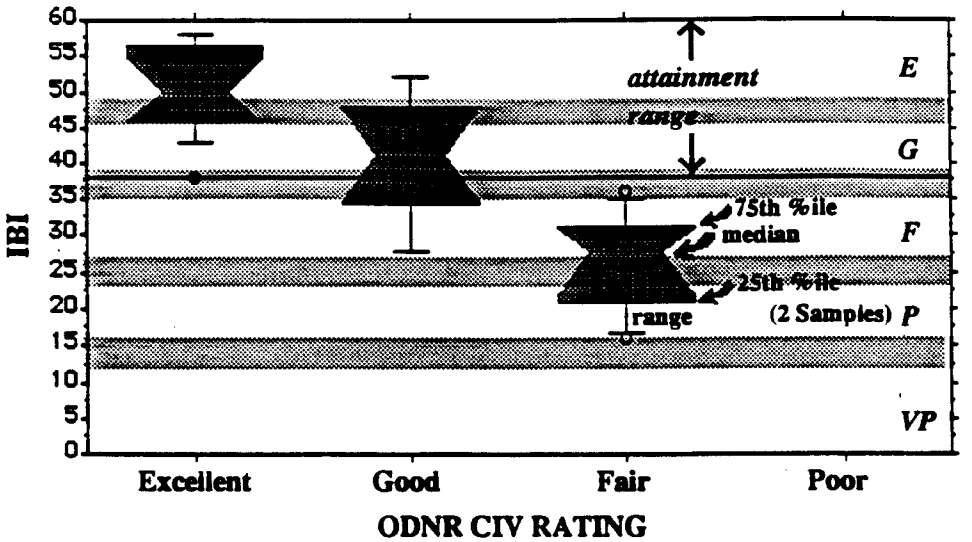


Figure 5. Notched box plots of Cumulative Index Value (CIV) qualitative ratings versus Index of Biotic Integrity (IBI) scores, 25th and 75th percentiles, IBI range, and IBI outliers (>2 interquartile ranges from median) for sites with drainage area ≤ 200 sq. mi. IBI qualitative ratings (exceptional, good, fair, poor, and very poor) appear on the right vertical axis. Shading indicates approximate boundaries between ratings and the variability of the index.

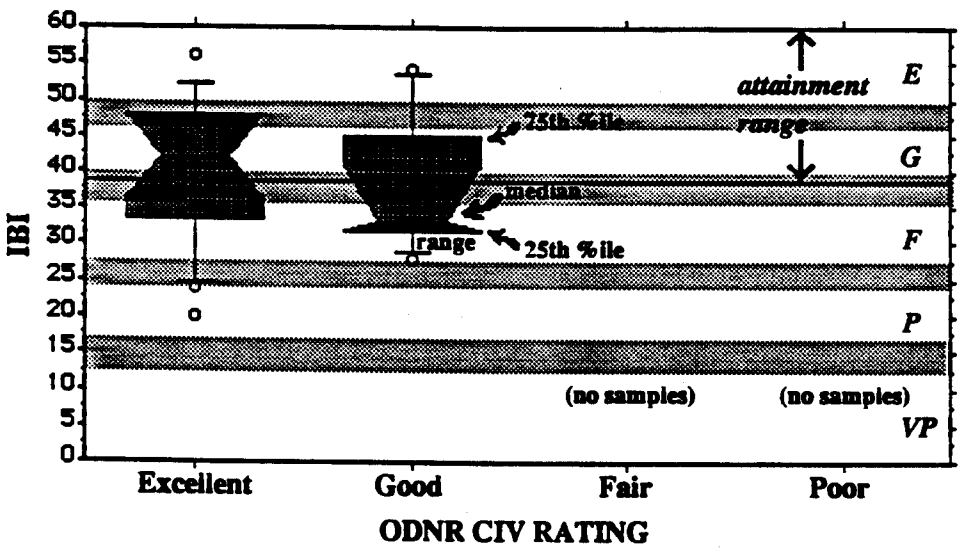
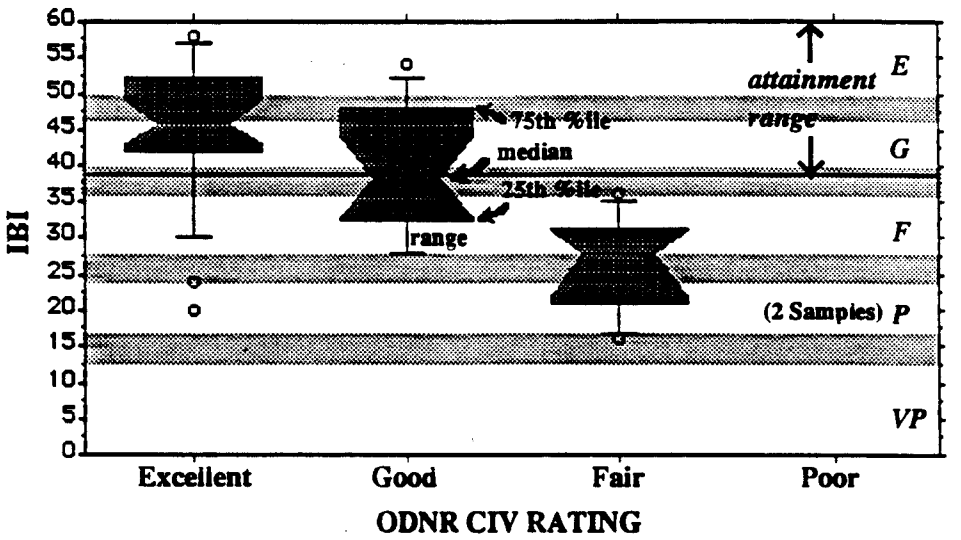


Figure 6. Notched box plots of Cumulative Index Value (CIV) qualitative ratings versus Index of Biotic Integrity (IBI) scores, 25th and 75th percentiles, IBI range, and IBI outliers (>2 interquartile ranges from median) for sites with drainage area > 200 sq. mi. IBI qualitative ratings (exceptional, good, fair, poor, and very poor) appear on the right vertical axis. Shading indicates approximate boundaries between ratings and the variability of the index.



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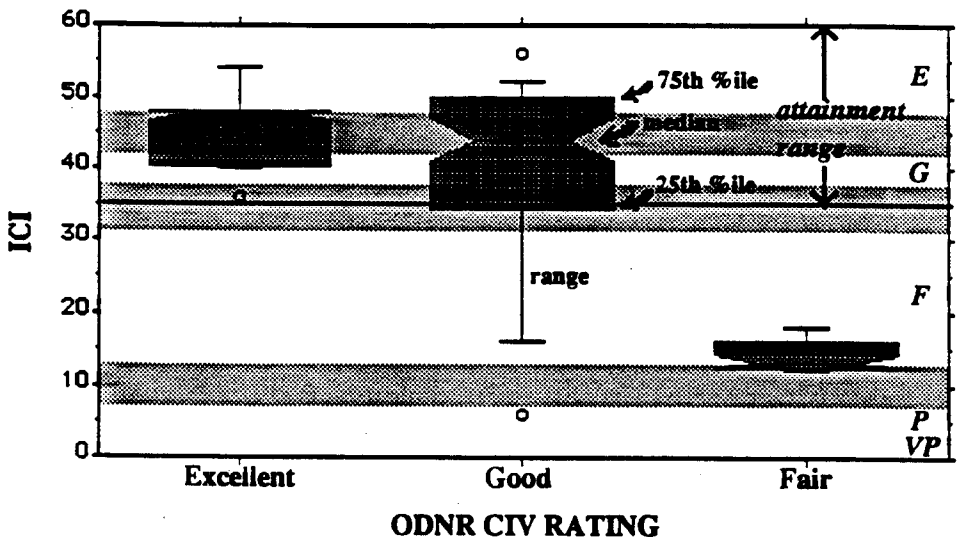

Figure 7. Notched box plots of Cumulative Index Value (CIV) qualitative ratings versus Invertebrate Community Index (ICI) scores, 25th and 75th percentiles, ICI range, and ICI outliers (>2 interquartile ranges from median). ICI qualitative ratings (exceptional, good, fair, poor, and very poor) appear on the right vertical axis. Shading indicates approximate boundaries between ratings and the variability of the index.

comparison with the ICI were present in the data set. Overall, there was a closer correlation (the ICI ranges for the CIV ratings were more defined) between ODNR's CIV ratings and the ICI than ODNR's ratings and the IBI. The "good" CIV rating still encompassed a large range of ICIs, however, and the actual CIV and ICI ratings did not always match.

The differences between ODNR and OEPA macroinvertebrate assessments may be due, in part, to the fact that the OEPA retains its collections for microscopic investigation and they are better able to locate and identify small early instar forms of these organisms. Another factor is that the OEPA researchers always make an attempt to sample a riffle, a run, and a pool area when performing their qualitative collection procedure. This could result in a higher diversity of organisms in their samples as compared to ODNR's samples, which are taken only from riffle areas. In addition, both the IBI and ICI incorporate a correction factor to adjust for drainage area impacts, while ODNR's technique does not. For the ICI/CIV comparison, drainage area impacts were not found to noticeably affect the correlation.

Comparison of Volunteer and Staff Assessments

Volunteer ratings tended to be higher than assessments made by ODNR staff members (Fig. 8). For sites rated "excellent" by staff, approximately 80% of volunteer CIVs fell in

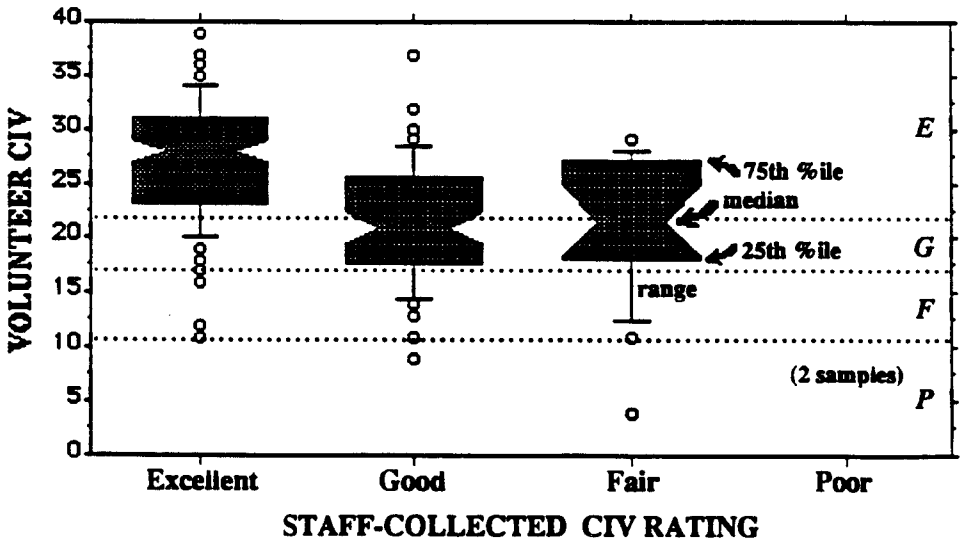

Figure 8. Notched box plots of ODNR staff ratings versus volunteer-generated Cumulative Index Values (CIVs), 25th and 75th percentiles, CIV range, and CIV outliers (>2 interquartile ranges from median). CIV qualitative ratings (excellent, good, fair, and poor) appear on the right vertical axis. Dashed lines indicate boundaries between ratings.

the excellent range, showing agreement. For sites rated "good" or "fair" by staff, the range of corresponding volunteer CIVs was wide, including CIVs which would be rated "fair" to "excellent." Differences between staff and volunteer ratings may be due to misidentification of organisms by volunteers, a misconception among program volunteers that water quality is always "excellent" in Ohio's Scenic Rivers (potential bias), or a greater sampling effort by volunteers as compared to staff members, who may rush through many reference sites in a day. In the Central Ohio area (ODNR's headquarters), stream quality monitoring coordinators have received better instruction on sampling strategy through frequent contact with program administrators and, as a result, the volunteer and staff assessments for this region showed closer agreement. This suggests that part of the reason for the general lack of agreement may be due to insufficient sampling by the ODNR stream quality monitoring coordinators, although all of the aforementioned factors probably contribute to the high variability of these results.

Summary

The qualitative ratings of ODNR's volunteer monitoring technique do not necessarily agree with the qualitative ratings of the OEPA. However, ODNR's CIV ratings do tend to reflect the attainment ("excellent" CIVs) or non-attainment ("fair" and "poor" CIVs) of aquatic life uses, as designated by the Ohio EPA, for both the IBI and the ICI. Hence, the assessments may be useful in screening sites at a basic level.

CIV ratings tend to reflect IBI ratings more accurately in streams and rivers with smaller

drainage areas. Drainage area did not appear to have a marked effect on the correlation between the CIV and ICI, but further collection of data could amplify an otherwise undetectable effect. Adequacy of sampling with the use of ODNR's technique may also affect the correlation. The results of this research suggest that larger drainage areas may require a modified approach, although determining exactly what that approach should entail is beyond the scope of this project.

A review of ODNR's database revealed that program volunteers tend to overrate the health of Ohio's Scenic Rivers as compared to staff assessments. This is probably due to a lack of standardization in the number of samples collected and misidentification of the organisms. These problems could be solved through more thorough training and better communication between ODNR, the regional coordinators, and the volunteers. To improve on the program, a measure of sampling effort and better quantitative estimates could be incorporated.

It should be noted that the range of observed CIV ratings used for the comparisons in this paper is constricted. There were relatively few sites which were rated "fair" or "poor" using ODNR's "kick-seine" method. Further collection of data will be necessary before suggestions of revisions to the scoring criteria or rating system can be made.

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